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Search for scalar top quark pair production in the top corridor region with CMS

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A search for scalar top quark (stop) pair production at the LHC is presented. This search targets a region of parameter space where the kinematics of stop pair production and top quark pair production are very similar because of the mass difference between the stop and the lightest neutralino being close to the top quark mass. The search is performed with the 2016 data set of proton-proton collisions at a centre-of-mass energy of 13 TeV, collected by the CMS detector, using events containing one electron-muon pair with opposite charge.

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1. Introduction

Supersymmetry is a promising extension of the standard model that introduce a relation between bosons and fermions and resolves some problems that the Standard Model (SM) cannot explain as the hierarchy problem. It also provides a dark matter candidate.

Different simplified models exist that describe the production of stop quark pairs, but this poster focuses on the so-called "T2tt" model from the Simplified Model Spectra (SMS), in which a 100% branching ratio is assumed for the stop to top + neutralino ($\tilde{\chi}_0$) decay.

First results with full Run 2 data set have been published, among them the following searches in three different final states, depends on the number of leptons: zero [1, 2], one [3] and two leptons [4] plus missing transverse energy in all of them because of the presence of $\tilde{\chi}_0$. With all of them excellent exclusion limits are achieved, excluding stop quarks with masses up to 1.2 TeV. But they are not sensitive in the so-called “top corridor”, where the mass difference between stop and $\tilde{\chi}_0$ is close to the top mass and signal and top pair production ($t\bar{t}$) has similar kinematics and it is very difficult to separate them. A dedicated search in this region is needed and it is presented in this poster [5].

2. Top corridor region search

The top corridor corresponds with events where the mass difference between stop and ($\tilde{\chi}_0$) is close to the top mass, so here signal and $t\bar{t}$ background have similar kinematics, especially at low $\tilde{\chi}_0$ masses. Therefore, signal events can only be detected as an excess on the $t\bar{t}$ cross section and it is important to have an accurate estimate to be sensitive to such SUSY signals.

In this analysis we look at signal models where the mass difference between the top squark and the LSP is equal or very close (7.5 GeV higher or lower) to the top quark mass.

This analysis uses 2016 data set and events are selected if they contain an opposite-sign electron-muon pair, so we have a dilepton final state. Then, to suppress Drell-Yan and other boson backgrounds, also are required at least two jets and at least one b-tag jet.

The main discriminating variable between signal and background is $m_{T2}(\ell\ell)$ which has an endpoint for $t\bar{t}$ at the W boson mass, so signal events are expected to populate the tails of the

distribution. Higher discrepancies between signal and $t\bar{t}$ appear at large values of the $m_{T2}(\ell\ell)$ distribution, and they are larger at high $\tilde{\chi}_0$ mass. The $m_{T2}(\ell\ell)$ observable is computed as:

$$m_{T2}(\ell\ell) = \min_{\vec{p}_{T,1}^{\,miss}+\vec{p}_{T,2}^{\,miss}=\vec{p}_{T}^{\,miss}} \left(\max\left[m_T(\vec{p}_T^{\,\ell 1}, \vec{p}_{T,1}^{\,miss}), m_T(\vec{p}_T^{\,\ell 2}, \vec{p}_{T,2}^{\,miss})\right]\right), \quad (1)$$

where m_T is the transverse mass, and $\vec{p}_{T1}^{\,miss}$ and $\vec{p}_{T2}^{\,miss}$ correspond to the estimated transverse momenta of two neutrinos that are presumed to determine the total $\vec{p}_T^{\,miss}$ of the event. The transverse mass is calculated for each lepton-neutrino pair, for different assumptions of the neutrino p_T.

More than 94% of the background comes from $t\bar{t}$ production. Therefore an accurate estimate is crucial to have sensitivity. This knowledge is achieved thanks to different MC comparisons with inclusive and differential cross-section measurements.

For the signal extraction the $m_{T2}(\ell\ell)$ distribution is used and no excess was observed. The exclusion limits at 95% confident level are calculated in the three diagonals of the region, and in the central one, the most difficult to separate from $t\bar{t}$ events, top squark masses are excluded up to 208 GeV. This means that in this analysis the full 'top corridor' region is not excluded, but this result significantly extends the exclusion limits of top squark searches to higher stop masses in this region that was previously unexplored.

3. Summary

This poster focuses on the dedicated search of stop quark pair production in the 'top corridor' region, where other analysis do not have enough sensitivity and exclusion limits are extended to higher stop quark masses. It also summarizes some of the last exclusion limits achieved by the CMS Collaboration with the full Run 2 data set for stop quark pair production on a simplified SUSY model assuming a 100% branching fraction to a top quark and a LSP, excluding stop quarks with masses up to 1.2 TeV.

References

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